IEEE–Franklin Institute Centennial Technical Convocation
October 1984
The Second Century Begins
Session III Priorities for the Second Century

R & D Management

George E. Pake
Group Vice President, Corporate Research Group, Xerox Corporation
October 9, 1984

As other speakers here have doubtless felt in preparing their remarks, attempting to produce thoughts applicable to a forthcoming century is an awesome task. One way to view our problem is to ask, "What would one have said about my topic in 1884 as 'The First Century Begins'?" And, if I could figure out an answer to that question, what meaning might that answer have had for the last few decades of the first century?

These questions posed some difficulty for me. I feel confident that the phrase "R & D Management" would have drawn puzzled reactions in 1884. First of all, the technical pioneers of those days were probably far less lazy grammatically than are we today. Since the New Deal was 50 years in the offering, the language had not been corrupted by "alphabet soup", and much less so by acronyms. Fortunately we do not normally attempt to pronounce R & D!

But even if one were to imagine speaking of Research and Development (rather than the cryptic R & D) in 1884, I have serious doubt that the two words were, in those days, frequently associated. The notion of research as a basis for development of products and services and the concept of a flow from research to development is, I suspect, entirely a 20th Century thought pattern. This gives me considerable pause: what will R & D connote in the year 2084?

I am sure that the word "Research" had full meaning to AIEE members in 1884, though it would not have brought to mind large industrial organizations of professionals, such as Drs. David and Gomory and I have responsibility for in our respective corporations. Those did not begin to appear until the first part of the twentieth century. Instead it would have had primarily an academic association. I am less sure what meanings (in a technological context) the word "Development" might have had.

My plan for this talk is, following the introductory reflections I have just sketched, to give you my definitions of **research** and of **development**, so that you will better understand what I am talking about. But my assigned topic also requires that I introduce and expand upon the ***management*** of R & D processes – surely a 20th century concept!

Research is the active, aggressive quest for knowledge or innovative concepts – if you do not consider it superfluous, I might say for new knowledge. In the context of the R & D process, people sometimes wish to make a distinction between at least two kinds of research: basic (or fundamental) research and applied research. Only occasionally do I find this a useful distinction. It is much dependent on the motivations of the investigators, and it is not an intrinsic property of the work or the resulting knowledge. Most of the results of so-called basic research find ultimate utility; does it then instantaneously transform to applied research? In some respects, I find it more useful to distinguish between long-range and short-range research. [Although most basic research is long range in its outlook, the converse is not true.]

Development, as a process step following research, is an organized effort to apply the new knowledge gained from research to devising a commercially or socially useful product or service. It therefore contains a healthy component of engineering. A senior level technological manager in my corporation made the distinction that, in our business context, research aims at expanding the

corporation's technological alternatives, whereas development seeks to narrow down or focus on a particular alternative, and of course to produce a cost-effective and reliable implementation.

Some other comments about distinctions between research and development: Research is more the province of scientists, and development of engineers. But each activity has substantial requirement for the experienced skills of both scientists and engineers.

Another point is that, in some elemental sense, development is more expensive than research. The design and construction of implementations requires, for hardware, the cutting, bending, or molding of metal or other structural materials and, for software, the careful production of reliable, debugged systems and programs – all of which consumes many person-hours of work by skilled professionals, and those person hours cost lots of money. The number of research person-hours required to generate and demonstrate at the bench a technology that forms the basis of a new product concept is typically very much smaller than to develop a durable, reliable, and manufacturable implementation of the concept.

But it would be wrong to conclude from this last statement that research budgets need only be a tiny fraction of development budgets. It takes a number of research investments (some of them quite long-term) before we pursue one that succeeds in exhibiting the potential for a new technology that enables a new product/service concept. And once a new technology is launched in the market place, a substantial on-going research effort is mandatory to provide the knowledge base for both sustaining and extending that technology in the field. So, as each research success is launched in the marketplace by a successful development effort, an added obligation falls to the research organization to build into its base program a sustaining/extending effort on behalf of the newly succeeding technology.

Now I come to what I regard as the most difficult aspect of discussing priorities for the second century: discussing the management of R & D. Management is certainly essential for Development, at least according to my definition. Recall that I characterized Development as an organized effort to focus down from research results to implementation of a new product or service. If the effort is organized, almost by definition it must be managed by the organizers. There are, indeed, plenty of challenges in this management task.

My problem is with the notion of managing research. I characterized research as the active quest for new knowledge and concepts. This means looking to the group of researchers for innovation and creativity. How does one manage this creativity of others? In my experience the attempt is quite often ineffective and often counter-productive. I believe that the role of management is to create and maintain an environment supportive of and encouraging to creativity and innovation. In fact, my brief prescription for managing industrial research would be something close to the following:

A. Recruit the best, most creative researchers you can find.

B. Give them the most supportive environment you can visualize providing. This includes ample amounts of the most advanced instrumentation. Holding tight on capital spending is a foolish attempt at economy – in fact it is a false economy compared to the costs of following principle A.

C. Work the business needs of the corporation into the program through selective budgetary preferences.

There is little success likely to come from showing researchers to a laboratory, describing in detail a desired technology or process not now existent, and commanding: "Thou shalt invent!" Instead, the enterprise seems to go better if some overall goals or needs are generally described and understood and

proposals for research projects or areas of investigation are solicited from the creative professionals. Managing the research then consists of adjusting the respective budgets for the projects or programs so as to give selective (and therefore sometimes differential) encouragement. There are many subjective criteria for this selective support, including of course the goal or objective of the project in relation to potential needs, and especially including the creativity, innovativeness, and productivity of the key researcher(s) on the team.

This recommendation for the selection process and differential budgetary tuning by the research manager or director of the research organization may seem, to a degree, to fly in the face of the time-honored advice of Dr. C. E. K. Mees, Vice President of Research for Eastman Kodak, who offered the following lessons from his experience, at a point almost precisely half way through the first century:

> "The best person to decide what research work shall be done is the man who is doing the research, and the next best person is the head of the department, who knows all about the subject and the work; after that you leave the field of the best people and start on increasingly worse groups, the first of these being the research director, who is probably wrong more than half the time; and then a committee, which is wrong most of the time; and finally, a committee of vice presidents of the company, which is wrong all the time."
>
> C.E.K. Mees
> Vice President, Research, Eastman Kodak
> October 22, 1935

In spite of my subscription to the principles set forth by Dr. Mees many years ago, I don't wander away and ignore my research groups and their scientists – nor did Dr. Mees. There is a very important role in guiding, challenging, and continually reassessing the selection process at all levels. And it is surely the

responsibility of research management to pose problems – or more likely the problem domains – that are of business importance to the corporation. When it comes to selecting projects, the research managment is, I believe, best advised to "tune" the research program by using the budgetary power to adjust emphases. In some cases that may mean shutting something off completely or occasionally giving birth to a whole new project or activity. But these steps should be taken with continual consultation and discussion up and down the entire hierarchy of research management – which after all is only three levels deep in each research center in my company.

To my mind, it is this all important process of selecting the research to work on, and allocating resources to it, that is the essence of what we call research managment. It draws upon the combination of technical knowledge, business strategies, research experience, understanding the psychological make-up of research scientists, and, above all, technical taste. The research manager, at any level, brings all of this to bear in a necessarily subjective way.

I have expressed my worry over how to have a vision on R & D management that can retain validity for a century. However, I am willing to make one prediction that parallels a significant event of the first century: the Institute changed its name, and I believe it will do so again in the second century. After being born as the American Institute of Electrical Engineers, the AIEE became the IEEE, the Institute of Electrical and Electronics Engineers. My prediction is that it will become something equivalent to the IEEEOE, the Institute of Electrical, Electronics, and Electro-Optical Engineers. This also tells us something about the nature of the new R & D domains that will become important for the present IEEE. At the beginning, long before the AIEE took steps to put the word Electronics (I am sure it should have been the adjective, Electronic!) in its name, people would possibly have had little reason to believe that research on electron processes in vacuum or, more recently, electron

energy bands and impurity states in semiconductors, would be relevant to electrical engineering. We have now arrived at a point where research on electro-optic materials and optical data transmission is quite germane to electrical engineering. As we see more and more applications of electro-optical phenomena, the name IEEEOE will become especially appropriate.

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A CENTURY OF ELECTRICAL PROGRESS

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SECOND CALL

IEEE - Franklin Institute
Centennial Technical Convocation

October 8-9, 1984

Franklin Institute
Philadelphia, PA

This coming Monday and Tuesday, October 8-9, The IEEE - Franklin Institute Centennial Technical Convocation will be held in historic Philadelphia. By joining us for just a day and a half you'll be able to explore the latest trends and expected developments in such areas as space, information and communication, medicine and biological systems, microelectronics, computers, energy and power conversion, integrated manufacturing technology, education and R&D management.

Plan now to take advantage of this extraordinary event. It's a unique opportunity to join industry leaders, distinguished engineers and scientists and Nobel Laureates as they mark the One Hundredth Anniversary of the electrical and electronics profession. Hosted by the Institute of Electrical and Electronics Engineers (IEEE) and the Franklin Institute, this historic Convocation will explore a century of progress in electrical technology and assess its expected future impact on human endeavor. In addition, you'll be able to view the opening of the three-month exhibition, Milestones of the Electrical Age, which will be held at The Franklin Institute Science Museum.

A copy of the program schedule for the Convocation is attached for your reference. To help you in your coverage, a pressroom will be maintained in the Board Room on the third floor of the Franklin Institute. Press registration for all Convocation functions is complimentary. Registration booths will be open on Sunday, October 7, from 1:00 P.M. to 8:00 P.M. in the Four Seasons Hotel. Registration Monday and Tuesday, October 8-9, will be at the Franklin Institute. Registration hours on Monday will be 9:00 A.M. to 5:00 P.M.; the hours for Tuesday will be 8:00 A.M. to 12 noon.

We do hope you'll join us next week for this landmark gathering. In planning for your news stories, here's where we think you'll get your potentially good leads....

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IMPACT OF THE INFORMATION AGE

William C. Hittinger, Executive Vice President of RCA Corporation, will discuss the emerging new information society and how changes contributed by the electronics and communications industries will impact education, industry, business, government and the role of the professional society. The need for heightened technical literacy will be assessed in light of a future scenario marked by profound change and required adaptation. Specific topics which Mr. Hittinger is expected to touch on include the impact of mechanization and automation, employment, the need for basic research, university education and questions relating to foreign trade.

SPACE EXPLORATION

Dr. Robert A. Frosch, Vice President of General Motors, will assess prospects for exploration and use of the solar system with emphasis on such activity on a self-sustaining basis. Dr. Frosch will emphasize the use of "space resources" in contrast with the use of our resources on earth.

INFORMATION TECHNOLOGY AND HUMAN ENDEAVOR

Dr. Robert W. Lucky, Executive Director of the Communications Sciences Research Division at AT&T Bell Laboratories, will explore how our lives will be affected by expanded and improved entertainment options in our homes, through mobile access to communications and by an information rich computer-aided office environment. In exploring the turbulent world of increasing change and expanded alternatives brought on by the information age, he will look at the driving technologies of microelectronics and optical communications, both of which have many orders of magnitude of expected improvement yet to come. According to Dr. Lucky, the future will be characterized by integrated voice, digital and image services, and by universal access to computer networks.

FUTURE TRENDS IN BIOMEDICAL TECHNOLOGY

Dr. Herman P. Schwan, Alfred Fitler Moore Professor of Biomedical Electronic Engineering, University of Pennsylvania, looks to the future and asks "How much are we willing to spend on biomedical technology?" While noting that "The sky is the limit" on what can be achieved, he points to a survey in the 1950s showing that Americans spent more money on electrical appliances than on medical technology. As he looks to the future, Dr. Schwan considers such techniques as ultrasonic imaging, computer axial tomography and nuclear magnetic resonance... but notes that dollars spent on medical technology must be balanced with benefits

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achieved. He will also discuss the constraints of such environmental factors as microwaves and high voltage lines.

KEYNOTE ADDRESS: "THE SECOND CENTURY BEGINS"

Dr. Bernard M. Oliver, Technical Consultant to the President of Hewlett-Packard Company, will review the accelerated developments of the electrical/electronics age and offer projections for the future. He will also assess possible social impacts of expected changes, including those relating to our educational system. Arguing for a strong background in technology as part of a well-rounded education, Dr. Oliver will support changes he believes essential in order to achieve future technological breakthroughs.

MICROELECTRONICS: THE NEXT 100 YEARS

Dr. Robert N. Noyce, Vice Chairman of Intel Corporation, will explore the next 100 years of microelectronics, including possible physical, economic and qualitative limits; he will also offer ways to get around such constraints. According to Dr. Noyce, certain current approaches using lithographic technology, the von Neumann architecture, and design methodologies may be "dead-ended"; biological models may offer lessons for future system organization and development. In addressing this theme, Dr. Noyce will discuss the coming cross-pollination among engineers, neurobiologists, computer scientists, and biochemists while also reflecting on social and ethical questions that the next century's microelectronics will inspire.

EVOLUTION OF COMPUTER SYSTEMS

Dr. Ralph E. Gomory, Vice President and Director of Research for IBM Corporation, will review the evolution of computer systems and related future trends. As part of his assessment he will explore those changes in hardware and architecture which are expected to contribute to rapid progress in tomorrow's systems. Dr. Gomory will also assess the critical nature of the human interface in such developments.

ENERGY AND POWER CONVERSION

Dr. R. David Middlebrook, Professor of Electrical Engineering at California Institute of Technology, will examine progress in reducing the size and cost of power supplies for today's smaller and smaller computers. He will assess the impact of such developments not only on computers but also on word processors and other "smart" equipment and will discuss how such breakthroughs open the door to efficient speed control in transportation and in industry in general.

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INTEGRATED MANUFACTURING TECHNOLOGY

Dr. Koji Kobayashi, Chairman of the Board and Chief Executive Officer of NEC Corporation, looks at the need to integrate today's manufacturing systems with the new technology of the information society. Such integration, according to Dr. Kobayashi, is a natural extension to the wedding of computers and communications, and will be necessary in the shaping of future systems designed to meet the expectations and demands of society.

EDUCATION

Dr. John G. Linvill, Co-Director of the Center for Integrated Systems at Stanford University, will assess three major priorities for education, including: (1) the change of education to "education for change"; (2) the use of technology to enhance technological education; (3) the development of incentives in the educational system. Incentives to be discussed by Dr. Linvill will be financial, honorific and programmatic in nature.

R&D MANAGEMENT

Dr. George E. Pake, Group Vice President for Corporate Research at Xerox Corporation, will discuss the future impact of research and development with special attention to those approaches which may be necessary in R&D management in order to achieve maximum progress. As Dr. Pake notes, although research and development are similar in many respects they also differ in fundamental ways. Clearly, development projects and programs need to be managed; but Dr. Pake poses the question, "Can creative research really be managed? If so, should it be?"

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Historical Observance

Sunday Evening, October 7
6:00–9:00 p.m.
William Penn Gallery
Franklin Institute

Milestones of the Electrical Age

A Victorian lawn party and reception will celebrate the opening of a Franklin Institute historical exhibit. The exhibit is reminiscent of the original 1884 International Electrical Exhibition, also under Franklin Institute auspices, during which the initial IEEE technical meeting was held.

Displayed will be artifacts from The Franklin Institute Science Museum's extensive collection, including an Elihu Thomson dynamo from the 1880s and one of DeForest's 1906 original handmade audion tubes. Visitor-operated devices, hallmark of The Franklin Institute, will be in abundance, from static generators to logic gates. Fifteen major corporations are contributing exhibits to enhance the story.

Technical Program

Monday Afternoon,
October 8
1:30 p.m.
Lecture Hall
Franklin Institute

Opening Remarks

Bowen C. Dees, President Emeritus, The Franklin Institute

Opening Address

William C. Hittinger, Executive Vice President, RCA Corporation

Session I

Changing the System

Impact of electrical and electronics technologies on human endeavor in the second century

Chair: Bowen C. Dees

Space

Speaker:
Robert A. Frosch, Vice President, General Motors Corporation
Discussant:
James C. Fletcher, William K. Whiteford Professor of Energy Resources and Technology, University of Pittsburgh

Information and Communication

Speaker:
Robert W. Lucky, Executive Director, Research, Communications Sciences, AT&T Bell Laboratories
Discussant:
Leonard Kleinrock, Professor of Computer Science, University of California, Los Angeles

Medicine and Biological Systems

Speaker:
Herman P. Schwan, Alfred Fitler Moore Professor of Biomedical Electronic Engineering, University of Pennsylvania
Discussant:
Leon Kaufman, Professor of Physics and Director, Radiologic Imaging Laboratory, University of California, San Francisco

Monday Evening, October 8
Benjamin Franklin
National Memorial
Franklin Institute

The Second Century Banquet
6:00 p.m. Reception
6:45 p.m. Dinner

(Black Tie Optional)

Opening Comments—Dedication and Presentation of Commemorative Plaque

Richard J. Gowen, Interim President, Dakota State College; President, IEEE

Introduction of Keynote Speaker and Panelists

Edward E. David, Jr., President, Exxon Research and Engineering Company

Keynote Address

(nationally telecast)

Bernard M. Oliver, Technical Consultant to the President, Hewlett-Packard Company; Former President, IEEE

Panel

Joshua Lederberg, President, Rockefeller University; Nobel Laureate in Medicine

Alvin Toffler, Author

Charles H. Townes, Professor of Physics, University of California, Berkeley; Nobel Laureate in Physics

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Tuesday Morning, October 9
9:00 a.m.
Lecture Hall
Franklin Institute

Session II
Finding the Technologies

Major technical developments for the second century

Chair:

J. L. Everett, III, Chairman of the Board and Chief Executive Officer, Philadelphia Electric Company

Microelectronic Technologies

Speaker:

Robert N. Noyce, Vice Chairman, Intel Corporation

Discussant:

Carver A. Mead, Gordon and Betty Moore Professor of Computer Science, California Institute of Technology

Computers in the Large

Speaker:

Ralph E. Gomory, Vice President and Director of Research, IBM Corporation

Discussant:

Andries van Dam, Chairman, Department of Computer Science, Brown University

Energy and Power Conversion

Speaker:

R. David Middlebrook, Professor of Electrical Engineering, California Institute of Technology

Discussant:

John G. Kassakian, Associate Director, Electric Power System Engineering Laboratory, Massachusetts Institute of Technology

Tuesday, October 9
12:00 noon
Four Seasons Hotel

Convocation Luncheon

Tuesday Afternoon, October 9
1:30 p.m.
Lecture Hall
Franklin Institute

Session III
Priorities for the Second Century

Chair:
Richard T. Nalle, Jr., President, The Franklin Institute

Integrated Manufacturing Technology

Speaker:
Koji Kobayashi, Chairman of the Board and Chief Executive Officer, Nippon Electric Company, Ltd.
Discussant:
D. Raj Reddy, Director, Robotics Institute, Carnegie-Mellon University

Education

Speaker:
John G. Linvill, Co-Director, Center for Integrated Systems, Stanford University
Discussant:
John B. Slaughter, Chancellor, University of Maryland

R&D Management

Speaker:
George E. Pake, Group Vice President, Corporate Research, Xerox Corporation
Discussant:
George H. Heilmeier, Senior Vice President and Chief Technical Officer, Texas Instruments, Inc.